Applying IPD Lean Principals to Healthcare Capital Projects

Brad L. Bastin

School of Engineering and Technology

Purdue University Indianapolis

Committee Member	Approval Signature	Date
Veto M Ray, Co-Chair Director of Facilities Management Technology		
David Goodman, Co-Chair Associate Professor of Electrical and Computer Engineering Technology		
Elaine Cooney, Member Professor of Electrical and Computer Engineering Technology		

Abstract

Over the last 15-25 years, lean principals have evolved and been applied and promoted to the construction industry through organizations like the Lean Construction Institute (LCI). This project will demonstrate how these proven lean management principles and integrated project delivery (IPD) provide a successful alternative for delivering healthcare capital projects. In the right context, integrated project delivery and lean construction process can significantly benefit the healthcare construction industry.

When planning lean projects, the project team must consider what tools and processes will be applied. The main drivers regarding lean and integrated project delivery are the owner's appetite for lean, project budget, stakeholder culture, and the project size. These variables will determine the level of lean intensity and process integration.

Keywords: Lean Construction Management, IDP

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Introduction

Over the last several years, there has been a growing trend and commonly held belief that the construction industry is broken and fractured when delivering projects. In this fractured system, project teams struggle to successfully convert the design into projects that meet the owners' needs. Historically the delivery methods such as Design-Bid-Build**,** Design-Build, and Construction Management at Risk have been utilized with mixed results. Some of the delivery models' shortcomings include failures to meet the project budget, schedule, quality, and owner goals.

Integrated project delivery is a framework for project collaboration. The spectrum of the IPD framework extends from historically collaborative project tools and techniques to a multi-party agreement that obligates the owner, designer, contractor, and trade partners to contractually collaborate through project validation, target value design, building information modeling (BIM), co-location, sharing in the projects risks/profits, and working from a cost basis delivery model (Michael Kenig 2010).

Lean construction processes are production management techniques that have evolved from the automotive industry, specifically the Toyota Way and Just-in-Time delivery philosophies. Through these management philosophies, construction industry production has been redefined from transformational conversion (input to output) to a management system that sees production as a series of flow processes that must be shielded from constraints to reduce waste (non-value activities) (Ballard G. & Howell G. 1997).

Problem Statement

The cost and complexity of Healthcare construction in the United States is rising, and project teams are not delivering value to the owner. One way to manage these issues is to utilize integrated project delivery and lean processes, however, no detailed research or matrix summarizes which direction the project team should take when implementing these lean tools.

Significance.

In 2004 the construction user's roundtable (CURT) commissioned a study by their architectural/engineering productivity committee to review issues their organizational members experienced within the construction industry, including inadequate and poorly coordinated construction

drawings, subpar schedule performance, and cost overruns. Through this study, they articulated the following goal for the construction industry:

"The goal of everyone in the industry should be better, faster, more capable project delivery created by fully integrated, collaborative teams. Owners must be the ones to drive this change by leading the creation of collaborative, cross-functional teams comprised of design, construction, and facility management professionals" (Curt 2004)."

Like Ballard and Howell, in their research of competing construction management paradigms, our industry should strive to " develop and deploy a new way of thinking about and practicing project management" (Ballard and Howell 2003).

Literature Review.

Rising Cost of Healthcare Construction

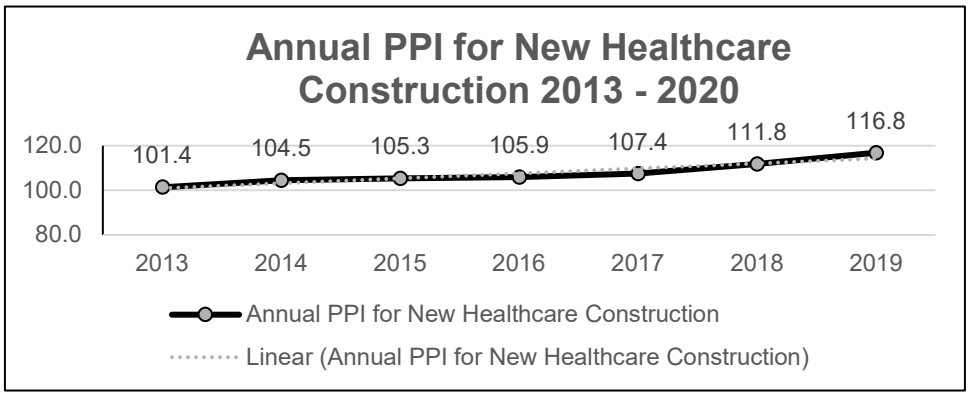

Figure 1 U.S. Bureau of Labor Statistics – PPI Data for Healthcare Building Construction

The cost of healthcare construction is rising. The Bureau of Labor Statistics (BLS) expanded the producer price index (PPI) to include an index that measures changes in the output prices of new healthcare building construction. As one can see from the attached model, healthcare construction pricing inflation has increased yearly since 2013.

Compared to other industries, the construction industry is lagging when discussing productivity and process improvement. According to the Oxford University Business school, 90% of U.K. infrastructure projects are over budget or late. Apple's new headquarters was two years late and 2 billion over budget. According to McKinsey, value-added construction production has increased by only 1% a year, 1/4 the manufacturing growth rate. Construction productivity has declined since the 1960s (Least Improved 2017).

Healthcare Capital Project Complexity

Healthcare facilities are complicated due to all the systems required to maintain an environment for providing quality healthcare for patients. An example would be sophisticated HVAC system to maintain proper air changes and space pressurization. Hospitals are "defend in place" facilities, therefore special considerations and redundancy are considered when designing the facility for 24-hr operation (Jones 2008).

Healthcare Capital Project Team Alignment

Team alignment is essential when delivering healthcare capital projects. Project success and failure are typically due to how well the project team is aligned. Usually, the need for growth, service line expansion, or infrastructure is immediate. The urgency for these needs is managed by accelerating the project schedule to minimize disruptions to the existing patient services. Within this urgent context selecting and establishing the correct project team is extremely important and challenging. The typical approach has been the construction manager at risk (CMAR). The construction manager is brought on board early in the design phase to collaborate with the design team and generate a guaranteed maximum price with partially completed construction documents. To accelerate the schedule, the construction phase commences while design continues. As one can see, the success of this delivery model is measured by how accurate the GMP is, and how well the project team worked together during the design phase (Michael Kenig 2010).

Providing Value for the Owner

Conditions of satisfaction for healthcare capital projects is becoming extremely important. Planning, design, financing, and construction is challenging because funding for capital projects is becoming scarcer due to the uncertainty of where capital funds will come from. Therefore, hospital boards approach conditions of satisfaction with a "highest value/lowest dollar" approach within current funding constraints, which is not necessarily the best approach for delivering value for the end-user (Fabris 2012).

Conditions of Satisfaction

When discussing the conditions of satisfaction, you must consider the value proposition of the project. The value proposition is the benefit-cost analysis of the capital project for the healthcare network.

The value proposition describes the new outcome for patient experience, defines project scope, and how the capital project relates to the hospital's business strategy. The Conditions of Satisfaction (CoS) documents the owner's value proposition and generates measurable criteria for meeting these goals. These criteria can include goals to minimize RFI's, project change orders, and end-user items. The project CoS is a living document that serves to align the project team, define expected behaviors, and project culture. The CoS identifies what project success looks like for the project team and must be kept current. If the CoS is utilized properly, it will clearly define the team's value and focus, reducing wasted effort during the design and construction phase of a project (Twin 2020) (Hamzeh & Bergstrom 2010).

Lean Production System Background

Lauri Koskela produced research in the early 1990s regarding production philosophy. He examined the traditional conversion-based philosophy and alternative flow production philosophy based upon the Japanese Just-in-Time delivery. His research criticized the traditional model within the construction industry and attempted to apply the new production philosophy, stating construction should be viewed as a flow process and not successive conversions processes. Traditionally construction management has tried to improve competitiveness and market share by incrementally improving the conversion processes. However, when construction management practitioners approach our industry with the new mindset that construction activities are flow processes consisting of both waste and value-added conversion activities, the project team can improve production by eliminating non-value activities (e.g., waiting, storing inventory, moving material, and inspections) (Koskela 1992). Based upon this flow process philosophy model Ballard and Howell further theorized and developed the Last Planner System (LPS) for production management, waste reduction, and work stabilization. (Ballard and Howell 1997).

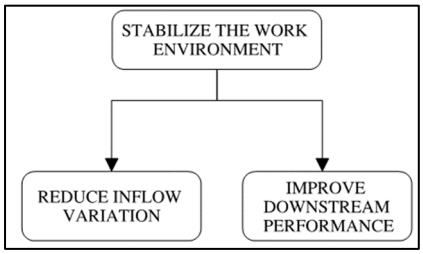

Figure 2 Stabilizing Workflow

The Last Planner System

The last planner system aims to engage all stakeholders in planning the project scope's execution. The LPS system is essentially a tool to plan, measure, and control the work taking place. The last planner system focuses on what "can" and "will" get done instead of what "should" be done. The project team is essentially "pulling" the work towards the trade partners and "shielding" production of

these tasks from constraints and waste that will hinder the completion of scope. Key principals include planning work incrementally (e.g., site, building envelope, framing to MEP in-wall rough-in, drywall installation through finishes), planning the work collaboratively with those performing the work, revealing and removing constraints from the flow of construction, making reliable promises, and measuring performance to improve learning & production (Ballard et al. 2007).

Once contracts are awarded, the construction manager moves through the procurement and buyout phase based upon what “should” and “can” be completed. Typically, this planning will encompass approximately 2-6 weeks of future work activities and is further exploded into weekly work plans, during which constraints are removed, and activities are completed (Ballard et al. 2007).

During construction the team reviews what "did" get accomplished and failures within the plan to control this whole process. Reasons for failure can typically be summarized. A root cause analysis is performed to help the team understand how changes in their behavior or actions will help prevent future failures within the project plan. This interactive process provides built-in agility by allowing the project team to measure real-time progress and adjust the project schedule accordingly (Ballard et al. 2007).

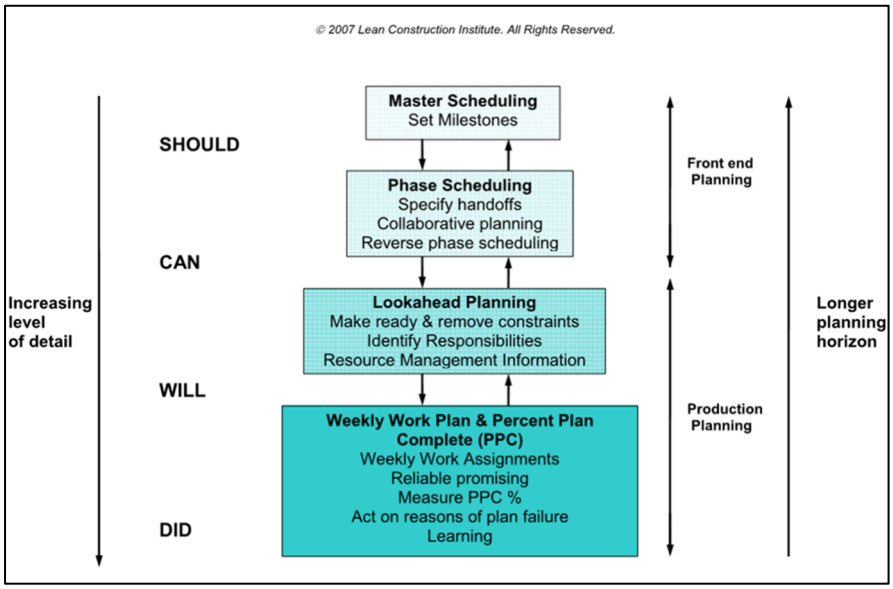

Figure 3 last Planner Life cycle indicating the increasing level of detail

Daily Huddle Meeting

In addition to utilizing the Last Planner System, project teams should take advantage of the daily huddle meeting, reinforcing commitments from the weekly work plans. According to Verne Harnish, the

daily huddle is very important for timely decisions. John D. Rockefeller used to walk to work with other co-founders of Standard Oil and talk about their organization's happenings. They found that several of the most important decisions of their company were made during these times. According to Verne, it's important to meet daily with your project team and to speak in specific details, not generalities (Harnish 2017). According to Bill Seed, a natural inclination in the construction industry, when problems arise, is to stop work and seek direction during the next progress meeting. This work stoppage derails workflow and contributes to trade partners missing milestone dates. Daily huddles help elevate this issue by verifying that work is progressing per the work plan and providing immediate resources. Daily huddles' benefits include keeping weekly commitments fresh in everyone's mind, sharing with the team safety concerns, project risks, and holding team members accountable. Daily huddles aren't problem-solving meetings but a forum to resolve immediate issues. The framework for huddle meetings should include discussions about what you've completed, what you're working on, and any constraints each trade partner encounters (Seed n.d.). Daily huddle meetings can be held on any project regardless of size, budget, or lean fluency of the owner or trade partners. Visual aids are helpful but aren't required. The only necessary tool needed for these meetings is the foremen performing the work and a superintendent leading the discussion. The goal of theses meeting is to increase communication among trade partners to make reliable promises and hold to their commitments.

Additional Lean Production Management Tools

Additional lean tools are available that project teams can utilize to maximize value and minimize waste within healthcare capital projects. These tools include establishing continuous improvement through A3 problem solving and a 5S program.

A3 Problem Solving

Continuous improvement is the process of benchmarking the current state of production on the project or within an organization and improving upon it. Within lean construction, this process is managed through A3 Problem Solving (Seed n.d.). The below table provides an overview of the steps required for this process:

A3 problem-solving Steps:

1. Value stream mapping the current state of the process
2. Utilize tools like brainstorming, plus/delta, fishbone diagrams to identify the cause and effect of waste identified through the value stream mapping process.
3. Utilize a Pareto chart to drill down the critical causes of waste
4. Through the plan, do check, and act (PDCA) process generate countermeasures and visualize the future state of these measures.
5. Once the countermeasures have been implemented follow up and review the results, make changes if needed.

5S Program

A 5S program is a plan to organize and declutter the project site to minimize waste and enhance productivity through visual control. The five "S"s stand for sort, set in order, shine, standardize, and sustain. The benefits of a 5s program include increased safety, higher equipment availability, lower defect rates, and increased production (ASQ).

Though these tools can be beneficial, they aren't necessary for a successful project. Small capital improvement projects typically don't have the luxury of time to sit down and conduct A3 Thinking & Reporting meetings beyond the standard foreman's meeting and daily huddles. Projects of a smaller scale can typically address issues during the normal course of business without additional research and reporting. Similarly, a 5S program isn't useful on a small capital project where material storage and management aren't necessarily an issue. Additionally, successful construction management firms and contractors already have internal processes and procedures established for their contractors' site logistics and workflow.

Building Information Modeling, Prefabrication, Co-location

Building Information Modeling (BIM) utilizes a 3-D model to help the project team with decision-making strategies. BIM benefits the project team by discovering conflicts and clashes early within the design phase, correcting these issues, and minimizing cost changes during the construction phase. BIM also allows trade partners to utilize the model for pre-fabricating portions of their project scopes, including Mechanical pipe racks, Restroom chases, and electrical conduit racks. The University Medical Center in New Orleans Louisiana is an example of BIM and prefabrication. Prefabricating large portions of scope allowed the project team to accelerate a 560,000 square-foot replacement hospital (Gokhale and Gormley 2014). Depending on the project size, BIM can be enhanced by co-locating the owner, design team, construction manager, and key trade partners to help with decision making. Co-location is where the

project team relocates its offices to one physical space during the design and construction. Co-locating benefits the project team by developing closer relationships between team members and improving communication regarding design and construction issues. All these benefits improve the latency during the BIM process (seed n.d.).

BIM is the future of the construction industry. It provides an excellent way to reduce changes during construction, improve coordination between trade partners, and reduce long-term maintenance issues by coordinating critical equipment like air handling units, boilers, and chillers. However, BIM isn't necessary for small scale capital projects. The costs for BIM management software can be very expensive, and depending on the contractors associated with the project, might be out of reach regarding the project team's capabilities. BIM also requires time to generate the model, detect clashes, and resolve design issues, all of which might not be included in a small capital project schedule.

Integrated Project Delivery (IPD)

Integrated Project Delivery (IPD) is very similar to concurrent engineering theories, and the project alliance delivery model. The focus is to parallel all parties within the early stages of design and construction and create a collaborative approach to delivering construction projects (Gokhale and Gormley 2014).

According to the American General Contracting Association, a project team can utilize three collaboration levels when trying to implement IPD. Within these three levels of collaboration, the owner sets the tone with how much integration will be utilized. Collaboration Level 1 is where the project team utilizes IPD philosophies to manage the project, including internal best practices used to create a collaborative environment through a traditional project delivery model. No real contractual responsibilities exist other than organizational culture. Collaboration Level 2 is enhanced integrated project delivery and throughout the industry is called IDP-lite, or IPD-ish. The team utilizes a traditional project delivery model based upon the project needs, including the utilization of Building Information Modeling (BIM), prefabrication,

Figure 4 Levels of Collaboration

and early participation of the trade partners. With Level 3 collaboration, the teams utilize a multi-party agreement; the project is strictly cost plus, a shared risk/reward system is in place, and the project team participates in "co-location" throughout the project (Kenig 2010).

The table below identifies the common foundational principles found within an integrated project delivery model either through organization culture (behavior) or contractually (Kenig 2010).

Organizational Lean Culture

Lisa Feeley, President of E2 Strategies, LLC, is a seasoned Six Sigma and Lean thinking Practitioner. When speaking with Lisa, she expressed the importance of Six Sigma and Lean thinking regarding delivering healthcare projects. It all starts with a team, the right mindset, and selecting the project's right tools and processes. According to Lisa, while delivering Healthcare projects, the team can control 85% of the issues and obstacles they face. According to Lisa, lean design and project management are here to stay within the construction industry. Design firms like Array, HKS, and BSA are implementing a full analytical team to address the IPD & Lean delivery models (L Feeley, personal communication, June 8, 2020).

With Atrium Health, Denton Wilson has fully integrated lean thinking into how Atrium Health deliveries healthcare capital projects. Denton applies lean collaboration to planning, design, and construction team members to deliver over 1.5 Billion in capital projects. According to Denton, healthcare-based project delivery is incredibly siloed, and subject matter experts abound. This arrangement can sometimes lead to adversarial relationships between the design professionals and the Construction Management team. Wilson believes it is the owner's role to work against this culture and create synergy and collaboration (Deeter S. 2019).

The Boldt Company has been involved with IPD and Lean construction practices since the late 1990s. According to Boldt, they have immersed themselves in lean thinking to drive waste from design and project delivery. Nick Loughrin, director of project development at the Boldt Company, has spent most of his career managing projects within the healthcare sector and focuses extensively on lean project delivery. According to Nick, success with Integrated Project Delivery and lean construction practices are driven by early team involvement on a project and having a robust lean culture within each party's respective organization. Regarding lean tools utilized throughout an IPD project, Boldt uses A3 thinking,

the last planner system, and 5S to eliminate waste during the project life cycle (N. Loughrin, Personal Communication, June 6, 2020).

Though lean tools are essential to lean construction, Nick emphasizes that culture is the most important. A lean mindset and organizational culture are what allow these tools to work. The project team must highlight breaking old habits when introducing and apply lean-to construction projects. You must train your team members to see waste as downtime and eliminate it. The project team must plan for continual team maintenance and continuous course-correcting to achieve the required benefits from Lean/IPD projects (N. Loughrin, Personal Communication, June 6, 2020).

Implementing Lean Culture

If an organization or project team wants to build a lean culture, it is crucial to teach and train employees not only about lean tools and techniques but principals, philosophies, and vocabulary. Ballard's research suggested several ways to implement lean on capital projects, including partnering with organizations that can adopt lean project delivery methods and structuring your organization to enable "downstream players to help with upstream decisions" (Hackler et al. 2017).

Successful lean projects have the overarching theme of aligning designers, contractors, trade partners with what matters to the client. Research suggests generating a professional lean curriculum and establishing re-occurring training sessions to educate employees is important to create a "critical mass" of stakeholders who understand and implement lean within the organization. Changing direction within an organization requires retooling how employees think. This change in direction needs to be performed by a lean champion within the lean committee. (Hackler et al. 2017).

Sutter Health Fairfield Medical Office Building in Fairfield, California

The Sutter Health Fairfield medical office building was a three-story 70,000 square-foot medical office building for primary care, medical procedures, laboratories, pediatrics, cardiology, and administration. Sutter Health partnered with HGA and the Boldt Construction company (both seasoned IPD & lean construction professionals) and entered a three-way integrated project contract (IFOA). The project shared risks and contingencies between the

Figure 5 Sutter Health Fairfield Medical Office Building

design firm and the contractor. An RFQ was issued for design during the spring of 2005, and the project was completed in December 2007. During the project's construction phase, the team utilized BIM coordination, lean techniques, and process management tools, including the Last Planner system and daily huddle meetings, to help the team collaborate and make reliable promises. (Gokhale and Gormley 2014).

Sutter Medical Office Building – New Construction – 70,000SF, Budget – N/A	
Lean Tools & Processes	**Experience**
• **Multi-party agreement** • **Building Information Modeling (BIM)** • **Laster Planner System** • **Daily Huddle Meetings**	• **Custom contract evolved from time consuming IPD agreement.** • **Created collaborative team, allowed for trade partners to prefabricate systems** • **Held the trade partners accountable to make reliable promises.** • **Helped the project team and trade partners coordinate and make incremental changes daily.**

Seattle Children's Hospital Costs

Figure 6 Seattle Children's Hospital

Seattle Children's Hospital started utilizing lean principles throughout their organization to create a continuous improvement mindset to improve the patient experience and lower healthcare costs by reducing waste operationally. They sought to push lean management through their facilities department to deliver the new clinical / surgery center's capital project. The first Program called for $100 million in funds and 110,000 square feet (S.F.). The project team's formation was established early in the project and approached this project with the initial goal of reducing the building S.F. by 30% and reducing construction costs to $70 million. The team utilized a multiphase value design process, including invaluable input from the user groups and BIM for coordination and planning to meet the hospital's goals.

Seattle Children's Hospital – New Construction – 75,000SF, Budget - $70,000,000	
Lean Tools and Processes	**Experience**
• **Building Information Modeling**	• **The Design process was integrated and lean. The project team utilized BIM extensively to manage the design phase.**
• **Pull Planning**	• **The project team utilized pull planning (like LPS) to manage and measure production**
• **Prefabrication**	• **Beneficial and reinforced by BIM and pull planning**
• **Daily Huddle Meetings**	• **Used extensively by user groups to maintain department and equipment schedules**

During the project's construction phase, the team utilized lean tools such as prefabrication and pull planning. (Wellman 2016).

Akron Children's Hospital Expansion

Akron Children's Hospital in Akron, Ohio, constructed a new addition to their hospital. The 2 ½ yearlong projects were designed by HKS and built by the Boldt Construction Company. The project delivery model was IPD, and the project team utilized lean processes extensively (Lean Construction Institute 2016). This project's preconstruction phase lasted approximately one year, including issuing the RFQ, establishing the IPD contract, IPD training for the project team, and validation of the project scope. The construction of the addition was approximately 1 ½ years in length. The benefit of the integrated project delivery processes included continuous feedback from the user group to provide value for the owner (Lean Construction Institute, 2016). According to Boldt Construction, IPD and lean construction are very influential and drive teams to collaborate in project-based thinking to deliver the project according to the owners' goals and values. Through the IPD framework, the project team made decisions and established mutual trust among all the project parties

Figure 7 Akron Children's Hospital

and stakeholders (Lean Construction Institute, 2016).

Akron Children's Hospital – New Construction – 365,000SF, Budget - $175,000,000	
Lean Tools and Processes	**Experience**
• **Multi-party agreement**	• **Custom Contract based upon the ConsensusDoc 300 and AIA 195. Agreement was beneficial, but required intense workshops and training and still lacked clarity among trade partners.**
• **Building Information Modeling**	• **The project team utilized BIM for clash detection and MEP coordination; however, owner felt the potential of BIM wasn't fully realized**
• **Last Planner System**	• **Project team utilized LPS to manage and measure production, beneficial for making reliable commitments**
• **Daily Huddles**	• **Beneficial and reinforced the Last Planner System**

Sutter Medical Office Building Los Gatos

Los Gatos is a 40,000SF 19.6-Million-dollar building situated in Los Gatos, CA. The structure is a medical office building and part of the Sutter Health Network. Los Gatos was originally a two-story core and shell facility which Sutter Health renovated to create a primary care clinic. The construction management firm and contractors hired by Sutter Health were very inexperienced with Lean and required training and workshops to incorporate lean into this project's construction. Sutter Health struggled to contractually obligate project team members to collaborate. Therefore, they adjust their approach to multi-party agreements and customized to fit their needs. The project team utilized various lean tools and processes to deliver this project, including conditions of satisfaction, BIM, the Last Planner System, to drive waste from the

Figure 8 Sutter Health Los Gatos

project and provide value for the owner (Lean Construction Institute, 2016).

Sutter Medical Office Building – Tenant Improvement - 44,000SF, Budget - $19,573,000	
Lean Tools & Processes	**Experience**
• **Multi-party agreement**	• **Custom contract evolved from time consuming IPD agreement**
• **Conditions of Satisfaction**	• **Helped team shift from quantitative goals to ones that were mission focused. Helped the team focus on the right correlations for success**
• **Building Information Modeling (BIM)**	• **Created collaborative team, allowed for trade partners to prefabricate systems**
• **Laster Planner System**	• **Required re-tooling by some trade partners but overall the team bought into this production management system.**

Hancock Regional Health

Hancock Regional Health Gateway Park is a Medical Office Building situated on the East Side of Indianapolis in Hancock County. This facility is dedicated to immediate care, imaging, diagnostics and administration space. The building sits on a 40-acre lot, and consists of three floors totaling 44,000SF of space with the 2nd floor prepped for tenet fit-out, and the 3rd floor dedicated to mechanical space for the air handling units and boilers. The construction consisted of structural steel, structural metal framing, and sheathing clad with four different types of metal wall panels. Overall, the lean process was beneficial for the construction management firm. BIM wasn't utilized to its full potential due to some trade partners' lack of BIM experience.

Figure 9 Hancock Regional Health Gateway

Hancock Regional Health – New Construction – 44,000SF, Budget - $15,000,000	
Lean Tools and Processes	**Experience**
• **Building Information Modeling**	• **The project team utilized BIM extensively to manage clashes and coordination of all the mechanical equipment in the penthouse**
• **Last Planner System**	• **The project team utilized LPS to streamline project workflow and manage weather delays**
• **Prefabrication**	• **Beneficial and reinforced by BIM**
• **Daily Huddle Meetings**	• **Helped trade partners keep commitments**

Purpose

The specific purpose of this capstone project is to review integrated project delivery and lean processes utilized to deliver healthcare capital construction projects. Research abounds within this subject, so my goal is to synthesize the lean literature and case studies presented in this paper and generate the following:

1. A lean matrix as a reference when applying lean to capital projects
2. Interview my employer to determine the current state of lean culture within my organization and establishing a Lean implementation plan for my organization
3. Create a Lean A3 for executive Leadership within my organization.

Definitions[1]

- **Building Informational Modeling (BIM)** - is a digital representation of the construction project utilized in design and construction. The AIA defines BIM as the process and technology to create the digital model. BIM is an excellent tool to aid in design and future planning of the facility
- **Co-Location –** is a project integration technique utilized to physically integrate the designers and the construction team in a single location to aid in project validation and target value design.
- **Constraints –** Constraints consist of prerequisite work, design, materials availability, and the construction activities' readiness. The make-ready process utilizes a constraint to log to remove activity constraints, shield work, and remove waste from the process.
- **Continuous Improvement –** This is an ongoing effort to improve products, services, processes to provide value. These efforts can be an incremental improvement over time or "break Through" improvements all at once.
- **Conventional Production Model** – Production is viewed as a conversion process of inputs to outputs.
- **Flow Process Model** – Production Philosophy where activities are extended to include Management processes
- **Integrated Project Delivery** – A project delivery approach that integrates all the decision-making project stakeholders to reduce waste and optimize efficiency through all phases of the project, from early design through project handover.
- **Lean** – Culture of respect and continuous improvement to create more value for the customer while identifying and eliminating waste
- **Just-in-Time** – A system for producing or delivering the right amount of parts or products at the time needed for production.

- **Non-Valued Added Activity –** is an activity that doesn't increase the worth of what is delivered to the owner.
- **Project Validation** – is the process where the project team, with the owner's business case in hand, aims at proving or disproving whether or not the project can be constructed within the owner's limits of scope, budget, and schedule constraints, and within an appropriate level of risk.
- **Target Value Design** – Collaborative design process with design professionals, construction management team, trade partners, and the owner co-located in one location to produce a project design provides the best value within the conditions of satisfaction framework.
- **Throughput** – The output rate of the production process.
- **Value** – What the Customer wants from the process. The customer defines value.
- **Waste** – The opposite of value. There are seven basic types of waste, including defects, waiting, transportation of goods, motion, inventory, overproduction, and unnecessary process steps.
- **Project Delivery Method**[2] – This is a system used by an agency or owner to organize, finance, design, and construct a capital project. This is a legal agreement with one or more entities or parties.

Assumptions

When researching this project, there were a few assumptions that must be considered:

1. Most of the research for lean projects are successful. The research is limited to unsuccessful IPD and Lean applications. Therefore, my assumption within this project is that most projects applying lean are successful
2. Countless project teams have implemented lean principals to deliver healthcare capital projects. However, I will only be focusing on Lean projects researched and studied through the Lean Construction Institute.
3. The initial assumption that the construction is fractured is back-up by research. However, countless projects are delivered with varied success utilizing traditional project delivery models. My focus within this project is Lean Construction and its advantages for Healthcare ownership and the construction partners.

Foot Notes:

1. Definitions have been adapted from the Lean Construction Institute www.Leanconstruction.org.
2. Definition provided via https://en.wikipedia.org/wiki/Project_delivery_method.

4. Except for the definitions section, this research is geared towards construction professionals and owners familiar with construction project delivery and the variety of delivery models utilized within construction.

Scope

Prices of building materials are not considered in this project research; this cost is subtracted from the value-added work. According to the Economist, material escalation has not risen significantly. In addition to material costs, variation in regulations and permitting was not considered either. The cost of permitting and regulations only contributes to a fraction of the production lost since 1987. Another variable affecting production, which is not considered in this report, is the construction industry's proportionate reliance on labor instead of machinery or capital equipment. The construction industry's volatility creates an environment for organizations to reduce fixed costs (to prepare for the next downturn) and rely on labor that can be terminated and is more variable in cost (Least Improved 2017).

Methodology (or Procedures)

The study and final report will consist of a literature review, conceptual analysis of pre-established research on lean construction, interviews with subject matter experts, synthesizing major points of lean application for healthcare organizations to apply on future capital projects. After summarizing the above information, I will conduct a baseline evaluation of my organization's utilization of Integrated Project Delivery and Lean and provide an implementation plan.

Results

Case Study Summary

When reviewing the case studies, the project teams "utilized IPD to create a framework for lean" (Seed n.d.) and lean tools to implement an iterative system where the team would plan, do, check, and act to deliver the capital project to their respective clients. Based on my review of the case studies, Integrated Project Delivery can be utilized with various intensity levels to create a framework for collaboration and the starting point for Lean processes and tools.

Owner Drive

Integrated project delivery is driven by the owner seeking an alternative delivery model other than the traditional CMAR model. As previously stated, project owners must be the ones to drive project

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integration by leading the creation of collaborative, cross-functional teams (Curt 2004). For example, project owners that are not engaged with lean tools and processes will not entertain the use of multi-party agreements, won't require the construction management firm and trade partners to implement the Last planner system for production management, and will resort to a "highest value / lowest dollar mindset." If the owner isn't engaged in lean, then typically, the only lean initiatives will come from the construction management firm to drive production through processes like BIM, Pre-manufacturing, and the Last Planner System.

Culture

Culture is extremely important when establishing lean on a project, if the owner, design firm, or construction partners aren't fluent regarding lean philosophy there is turbulence when trying to establish lean processes such as the multi-party agreement, Last Planner system, BIM, or co-location. For example, if the owner and construction management firm is trying to establish lean on a project and the trade partners aren't seasoned lean practitioners or fluent in lean, the project team will struggle to implement BIM, the Last Planner System, or understand the concepts of waste reduction and what value means for the project team.

Project Size

The project size is relevant when establishing Integrated project delivery and lean. Smaller project teams have less time and money to deliver capital projects and cannot afford lengthy Multi-party contract negotiations, BIM processes, co-location, or daily meetings with trade partners. The above case studies all have $20 Million + project budgets, including the time and resources necessary to establish lean processes, train staff, utilize BIM & co-location, and participate in lean construction's lengthy preconstruction phases.

Lean Project Management Matrix

I generated the below visual representation of lean intensity on capital projects and the variables that drive this intensity to help a lean practitioner determine the types of lean tools and processes required for the capital project they deliver internally or to an external Healthcare network. On the left side of the diagram, I've indicated project integration levels and the lean variables that drive lean on projects. These two columns correlate with each other, and as owner drive, culture, and project size

increases, so does the potential level of project integration. The inverted pyramid represents the tools and processes utilized during a lean project. I chose an inverted pyramid to represent the expanding capabilities of using lean on projects as the level of project integration and lean variables increases. The inverted pyramid is also useful because it all allows the practitioner to visually group lean tools and practices within the levels of integration. The right portion of the matrix provides the user a "quick guide" view of the lean tools and processes and considerations the lean practitioner should consider when analyzing how lean should be applied their respective capital project (Figure 10)

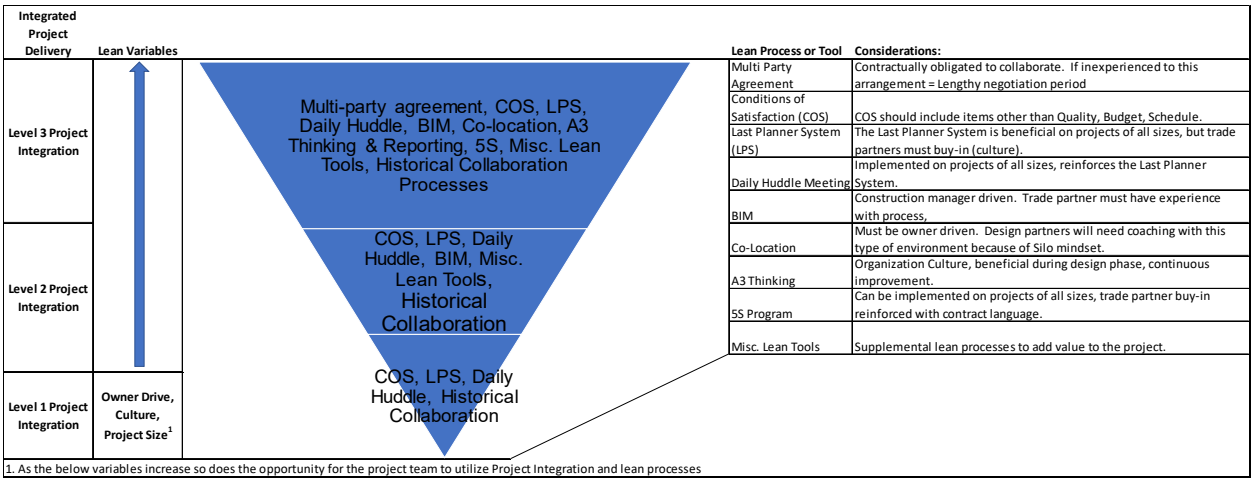

Figure 10 Lean Project Management Matrix

Recommendations

The tools and processes are flexibly utilized to deliver a lean construction project. However, the ingredient that is required for a successful lean project is culture. Culture is the greatest variable and the foundation stone to implementing project integration and lean. Culture includes experiences, values, and philosophy of an organization and is expressed in how it operates and interacts with the outside world. Therefore, if a construction management firm wants to establish lean principles and collaborate on IPD projects, culture must be created or a plan in place to integrate lean within the organization's operational structure. Developing a lean culture is akin to implementing other organizational changes and handled with a change management strategy. In coordination with my current employer, I conducted Interviews to establish the baseline lean culture within our organization and present the below change management plan to align the establishment of lean with our current business strategy.

Organizational Lean Change Management Plan

Lean Implementation Goal

Implementing lean on capital projects and within an organization requires aligning project organizational leadership, managers, and superintendents, to create something that brings value to the owner. The first step in this process includes making a case for change (Hackler et al. 2017). Therefore, to re-establish and implement a lean culture within my organization, I created the below case for my organization's change.

Case for Change[1]

Questions:	**Reasons for Change:**
• What's the current problem	• Poor Productivity, Lack of Accountability
• The Current State of the Organization	• High priority to meet project schedules, maintain a budget, and to meet the owner's quality requirements
• Risks of Not Acting	• Loss of market share, loss of clients due to not hitting their conditions of satisfaction
• Benefits of Acting	• We are becoming more agile and nimble as an organization. Greater client satisfaction.
• Organizational Goal	• To become a productive construction organization where we provide value to our clients by minimizing wasted effort, resources, money, movement, etc.…
• Organizational benefits	• We will become a collaborative organization where employees and our project teams are consistently hitting our financial, quality, and safety goals.
• Impact on Stakeholders	• More collaboration means less effort focusing on poor performers and more focus on safety, quality, and project goals

1. Table Adapted from University of California Change Management Toolkit

Current State of My organization

Once the case for change was created, I conducted an in-depth interview with my employer to review its current lean culture. I formulated the interview questions from the literature review and the interviews I conducted with Lisa Feeley and Nick Loughrin when discussing lean processes and culture.

Hagerman Construction Lean Culture Baseline	
Hagerman Construction's experience with IPD/Lean	• IPD-lite projects with Indianapolis healthcare partners 10-15% • Owner driven agreements • Lean Tools – Hagerman utilizes the Last Planner System to some extent, but not fully. Probably 10-15% of our projects utilize the last planner system. • Hagerman does not utilize Lean tools and processes extensively
How does Hagerman Construction implement reliability and accountability	• The project team generates a CPM schedule (built by the project manager and superintendent). The 3-week look ahead, and schedule are reviewed during the Foreman's meeting, and work activities are coordinated between the sub-contractors.
Current Lean Training & Culture	• A core group of a team member to receive lean green belt training to evaluate internal processes, set on committees, and drive process improvement throughout the organization. • Additional employees to participate in the Lean Construction Institute
Current utilization of Lean Tools: • IPD Philosophy or contract • BIM & Co-Location. • Conditions of Satisfaction (COS) • Last Planner System – partially • 5S program (sort set in order, shine, standardize, sustain) • A3 Thinking	• Utilizes IPD-lite contracts when required by the owner • In the beginning stages of implementing BIM, rarely utilizes Co-location • Partially utilizes LPS on approximately 10-15% of the projects • Doesn't utilize 5S • Doesn't utilize A3 thinking

Prioritizing Lean Process Training Through the Analytical Hierarchy Process

The Analytical Hierarchy Process (AHP) is a process where you remove the subjectivity from decision making by calculating discrete numerical quantifications of decisions pairwise (evaluating two at a time). By my personal experience and the interview conversation I conducted with Hagerman Construction, I calculated the following IPD & lean techniques, which should be evaluated and implemented as the foundational tools to start our organization's lean journey. When reviewing the below table, each Lean process was categorized and evaluated to generate a priority percentage (%). The highest percentage processes represent the processes that our organization should focus on when implementing our lean training plan.

AHP Priority Calculator[1]

Cat		Priority	Rank	(+)	(-)
1	Integrated Project Delivery (IPD)	2.7%	7	1.4%	1.4%
2	IPD-Lite	9.7%	5	5.3%	5.3%
3	Building Information Modeling (BIM)	10.4%	4	5.2%	5.2%
4	A3 Problem Solving	11.4%	3	2.7%	2.7%
5	Last Planner - Work Flow Stabilization	30.8%	1	10.6%	10.6%
6	Conditions of Satisfaction (COS)	29.4%	2	13.1%	13.1%
7	5S Program	5.7%	6	3.7%	3.7%

1. Goepel, K.D. (2018). Implementation of an Online Software Tool for the Analytic Hierarchy Process (AHP-OS). International Journal of the Analytic Hierarchy Process, Vol. 10 Issue 3 2018, pp 469-487, https://doi.org/10.13033/ijahp.v10i3.590

Implementation Plan

After I created the case for change, established my organization's current state of lean application, and prioritized which Lean processes and tools should be focused on within my organization, I generated an Implementation plan for creating and maintaining lean practitioners within our

Implementing Lean Road Map[1]

- **Create a Lean team** – Select a core group of organizational leaders to become aware of Lean philosophy and principles. Learn the history, terminology, and understand where the principals come from.
  - The Lean team need to include executive leadership such as project executives, project managers, and superintendents:
  - Project Executives to champion lean philosophy to their project teams trickle down lean throughout the organization to support staff (accounting, HR, etc…).
  - Project managers and superintendents to drive lean on their projects, and to eventually lead contractor training.
- **Practice, Teach, and Learn** – Learn tools and processes.
  - These training sessions can be held within the organization's training facility on a regular basis, depending on the current knowledge and background in regards to lean. The focus of these training sessions should be the Last Planner System and implementing Conditions of Satisfaction (CoS)
  - At a minimum one representative form the lean team should be involved within the LCI Central Indiana Community of Practice to stay current with lean education, continuously learning, networking, and connecting with local lean practitioners.
  - https://www.leanconstruction.org/local-communities/central-indiana-2/
- **Simulation & Test Projects** – Work through simulation workshops with select personal that will be implementing the Last Planner System and CoS on their projects.
  - Start to implement Lean practices on pilot projects.
- **Expand Offerings** – Once our organization has started to implement Lean on pilot projects, start to widen the circle of Lean practitioners within the organization.
- **Maintain Lean Competencies** – Participate within a local Community of Practice (CoP) to share information, improve skills, network, develop personal relationships.

organization. The plan was adapted from "Building a Lean Culture," and represents a trickle-down effect of educating a core group of lean practitioners within my organization, establishing a continuing education program for a small group of project managers and superintendents, and then expanding lean education offerings throughout our organization to create a critical mass of lean practitioners.

1. Adapted from "Building a Lean Culture" https://iglcstorage.blob.core.windows.net/papers/iglc-06fdf861-bc12-41ca-afca-21272b506365.pdf

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Figure 2. - Koskela, Lauri. (2000). An Exploration Towards a Production Theory and its Application to Construction. VTT Publications

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Figure 5 - Ballard, Glenn & Hamzeh, Farook & Tommelein, Iris. (2007). The Last Planner Production Workbook-Improving Reliability in Planning and Workflow. Lean Construction Institute, San Francisco, California, USA.

Figure 6 - Michael Kenig (2010) American General Contractors Association: Integrated Project Delivery for Public and Private Owners. Retrieved From: https://www.agc.org/integrated-project-delivery

Figure 7 – Sutter Fairfield Medical Campus. Retrieved from https://www.sutterhealth.org/find-location/facility/sutter-fairfield-medical-campus

Figure 8 – Seattle Children's Bellevue Clinic. Retrieved from https://www.bellevuedowntown.com/go/seattlechildrens

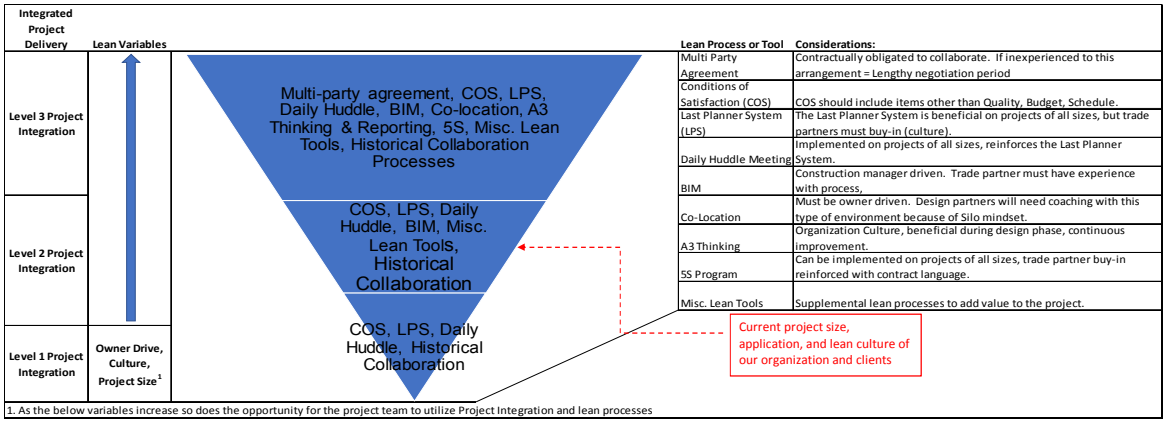
Figure 9 – Akron Children's Hospital. Retrieved from https://www.akronchildrens.org/

Figure 10 – Based on my research into applying lean to capital projects of all shapes and sizes.

A3 - Implementing Lean on Healthcare Capital Projects

Background Information:

healthcare Projects are costly, complex, and require team alignment. Lean is a successful alternative for delivering Healthcare capital projects, and there are a variety of tools and processes to choose from.



Lean Process or Tool	Considerations:
Multi Party Agreement	Contractually obligated to collaborate. If inexperienced to this arrangement = Lengthy negotiation period
Conditions of Satisfaction (COS)	COS should include items other than Quality, Budget, Schedule.
Last Planner System (LPS)	The Last Planner System is beneficial on projects of all sizes, but trade partners must buy-in (culture).
Daily Huddle Meeting	Implemented on projects of all sizes, reinforces the Last Planner System.
BIM	Construction manager driven. Trade partner must have experience with process,
Co-Location	Must be owner driven. Design partners will need coaching with this type of environment because of Silo mindset.
A3 Thinking	Organization Culture, beneficial during design phase, continuous improvement.
5S Program	Can be implemented on projects of all sizes, trade partner buy-in reinforced with contract language.
Misc. Lean Tools	Supplemental lean processes to add value to the project.

1. As the below variables increase so does the opportunity for the project team to utilize Project Integration and lean processes

Current Condition:

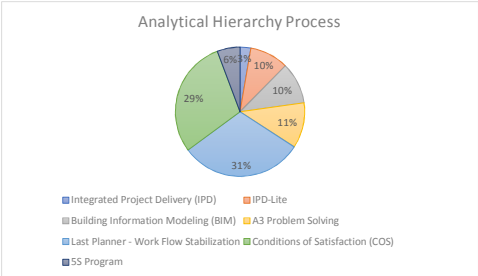
Currently our organization is applying lean project management to 10-15% of our healthcare projects. Superintendents and project managers are partially engaged with Lean.

Goals:

Current goal is to implement training periodically to maintain and improve current lean culture within our organization.

Root Cause:

1. Lean isn't a large part of our organization culture
2. Lean isn't a major requirement from our Healthcare clients
3. Current Project Management tools include CPM scheduling, Command, Control



Out of all the essential lean processes and tools, our lean team established that focusing on the Last Planner System and COS is of the highest priority

Counter measures:

1. Empower Lean team – Core group of organizational leaders to become more aware of Lean philosophy and principles
2. Training sessions held at the Hagerman Institute on a regular basis (quarterly). Focus these training sessions on the Last Planner System and Conditions of Satisfaction (CoS)
3. Representative from the lean team should be involved within the LCI Central Indiana Community of Practice to stay current with lean education
4. Implement Lean practices on select projects.

Initiative Schedule:

(Months)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Quarterly Lean Meetings				■				■				■				■	
Training Sessions as required																	
LCI Involvement (As Required)																	
Implement LPS on Capital Project	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Follow-up:

1. Follow with Senior Management on Successes including schedule & budget improvements